



# Stress and flexibility of bayonets, control valves, and supports

Pawel Duda / Wroclaw University of Science and Technology

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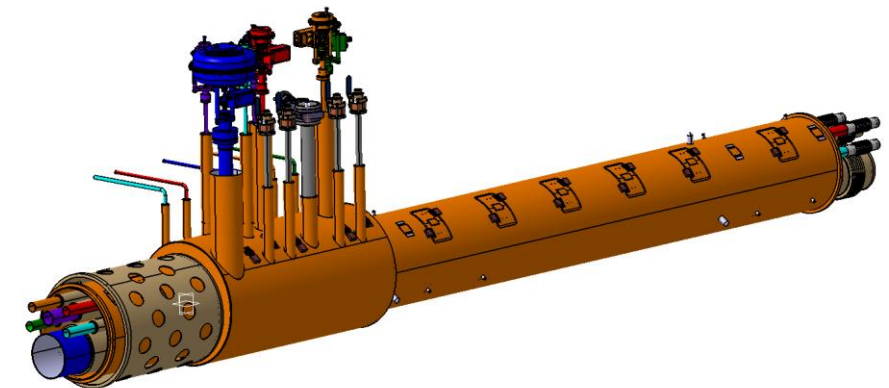
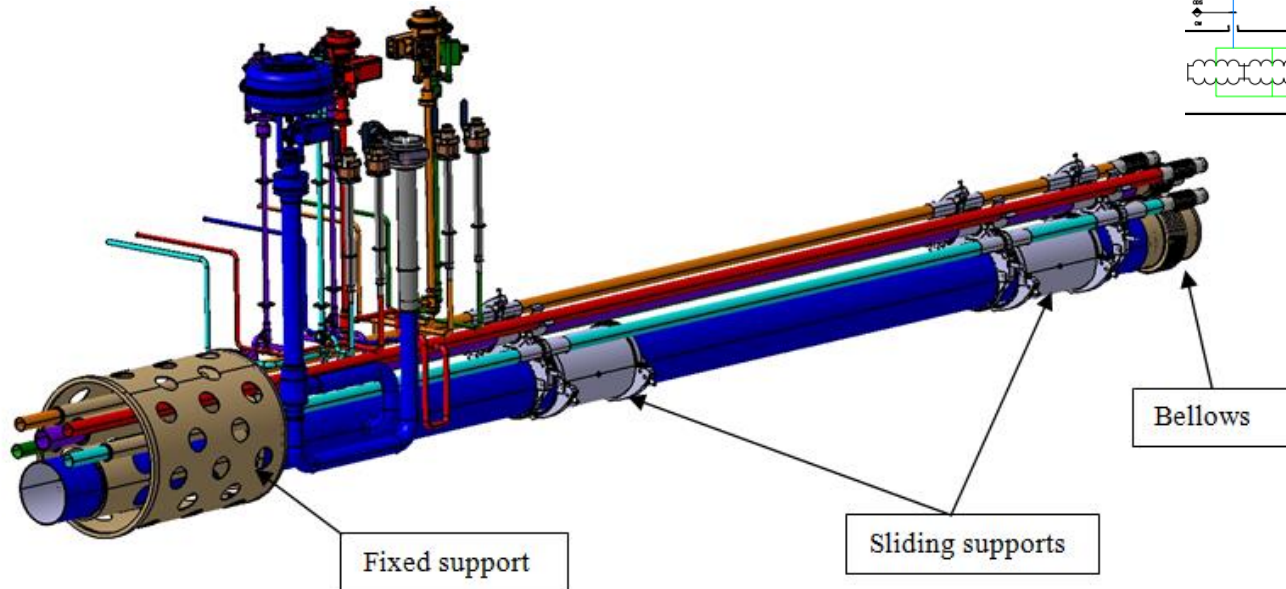
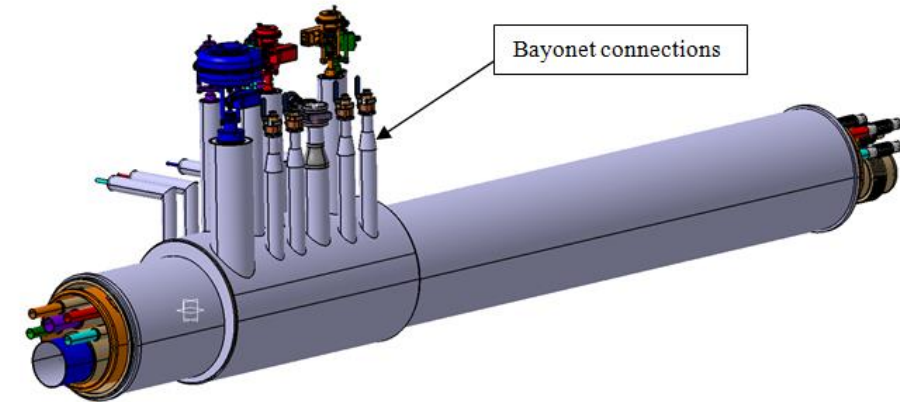
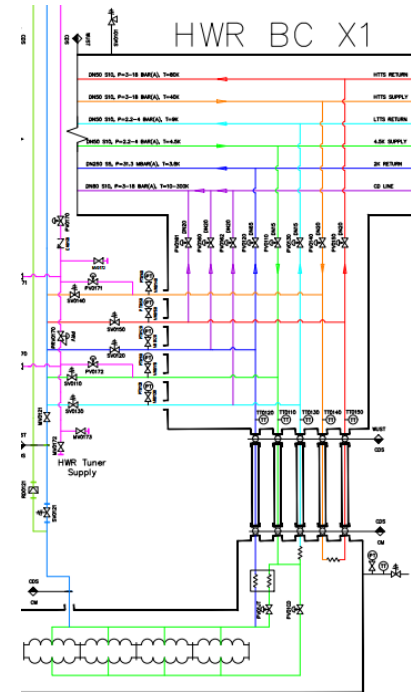
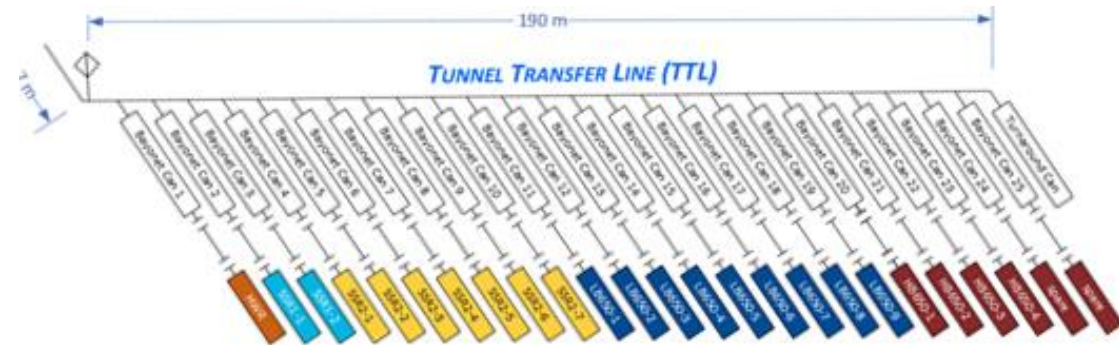
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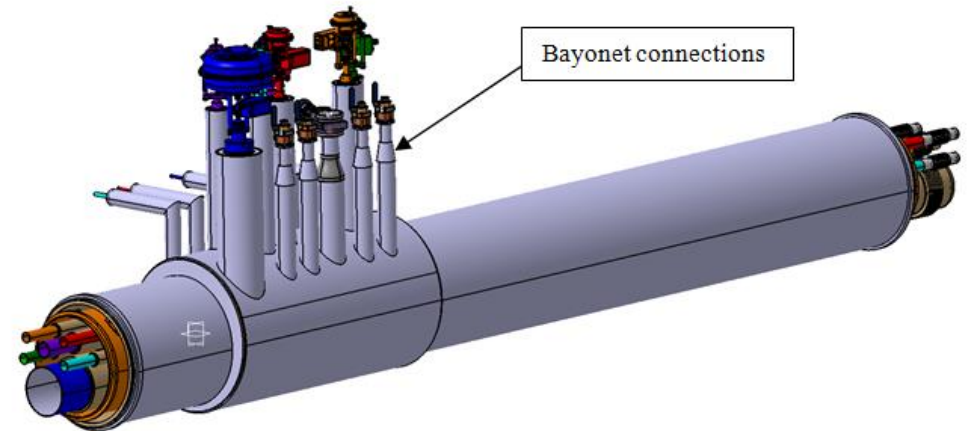
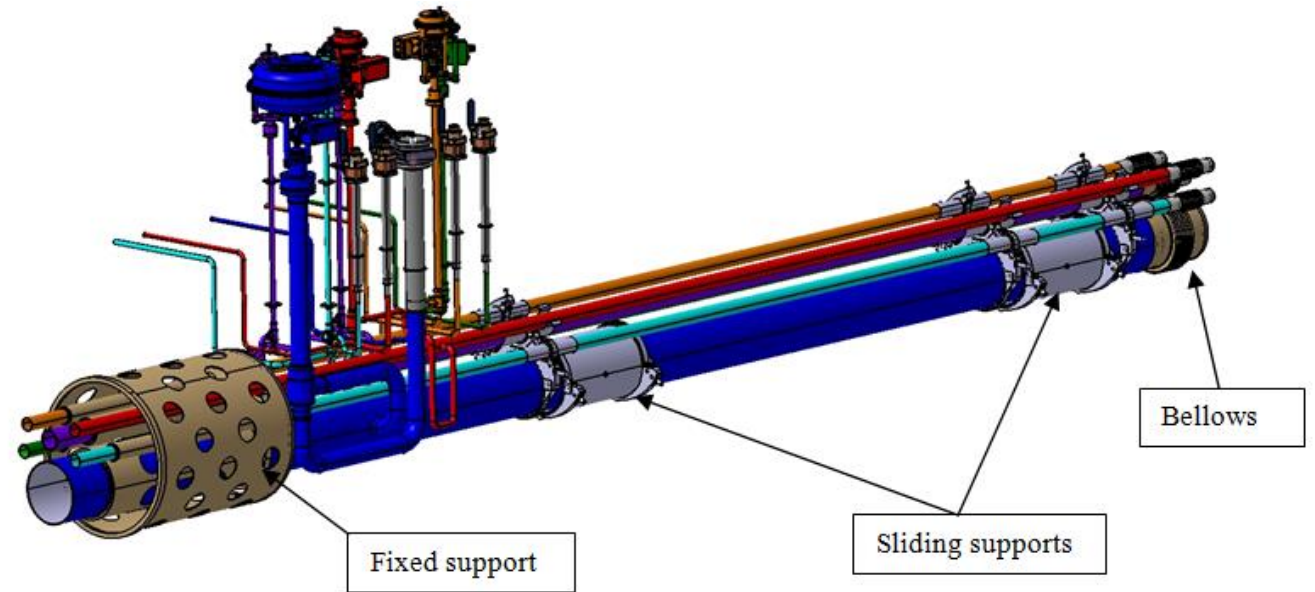
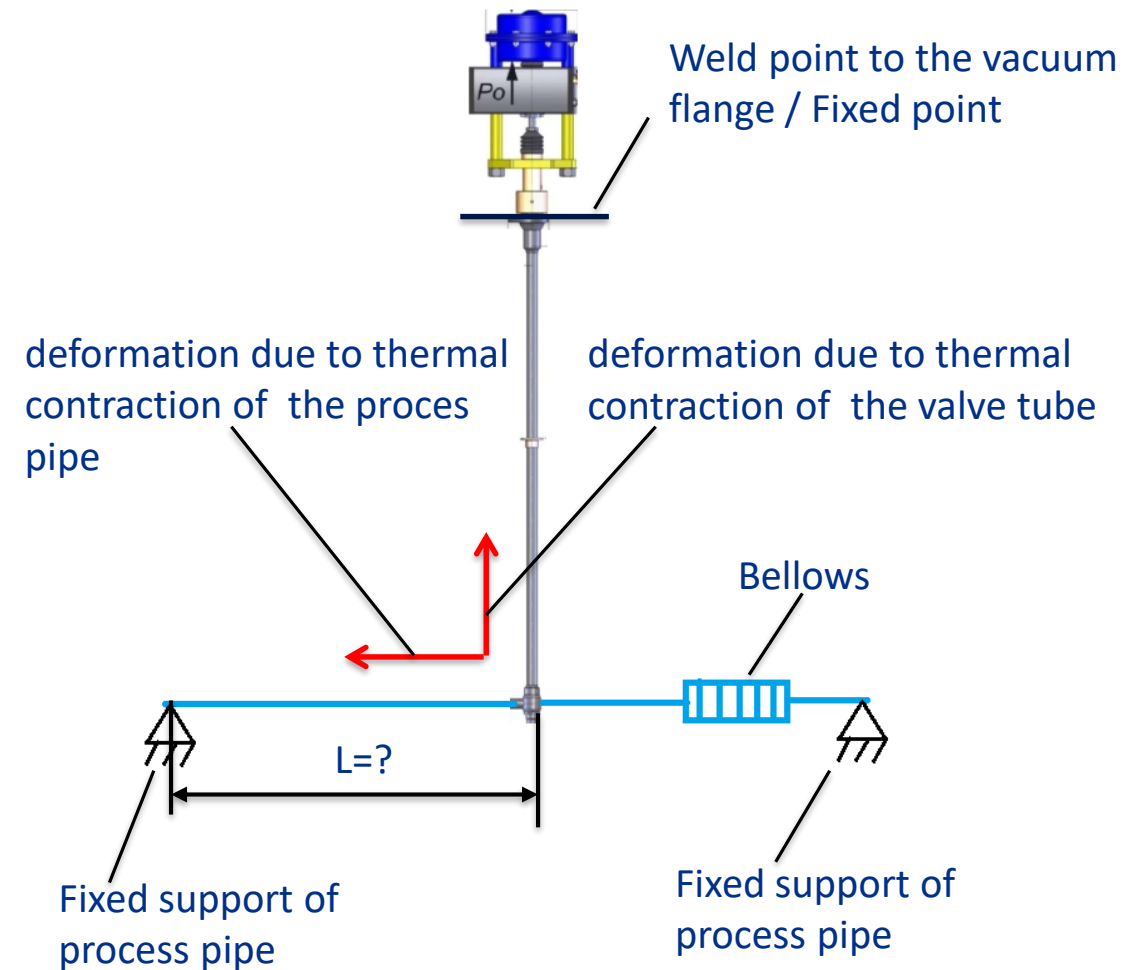


# Bayonet Can 3D model introduction

Bayonet Can is a link between the Cryomodule and the Cryogenic Transfer Line

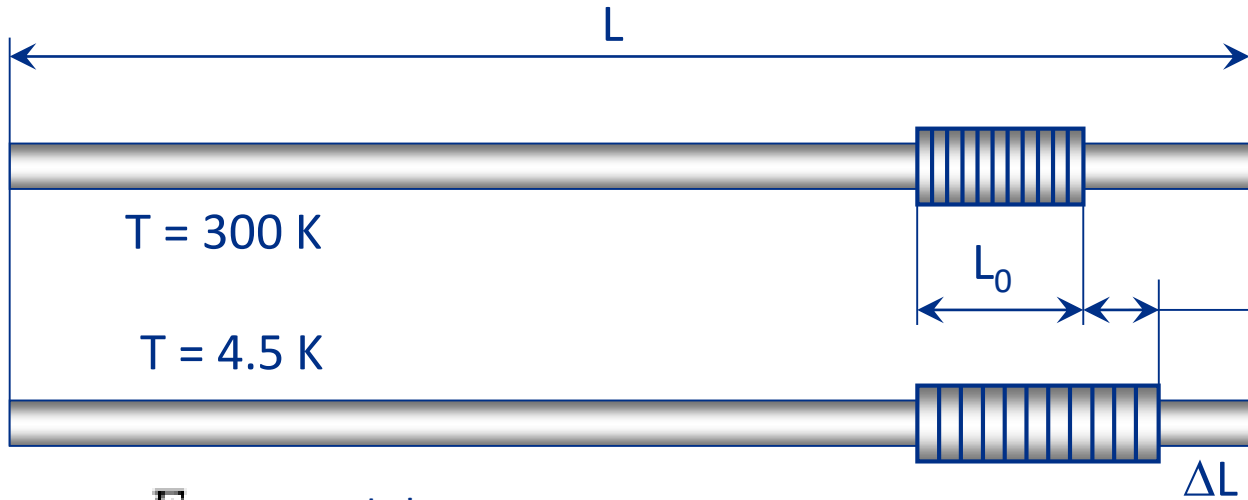


# What is the best location for valves and bayonets?



**The thermal contraction at the connection point of the valve/ bayonet with the process pipe should be as small as possible**

# Stresses generated by thermal contraction



$$\sigma = E\epsilon \quad \text{- Hooke's Law}$$

$$\epsilon = \frac{\Delta l}{l} \quad \text{- strain (depends on material properties)}$$

$$\frac{F}{S} = E \frac{\Delta l}{l}, \quad \text{- The force } F \text{ is constant and independent of } L$$

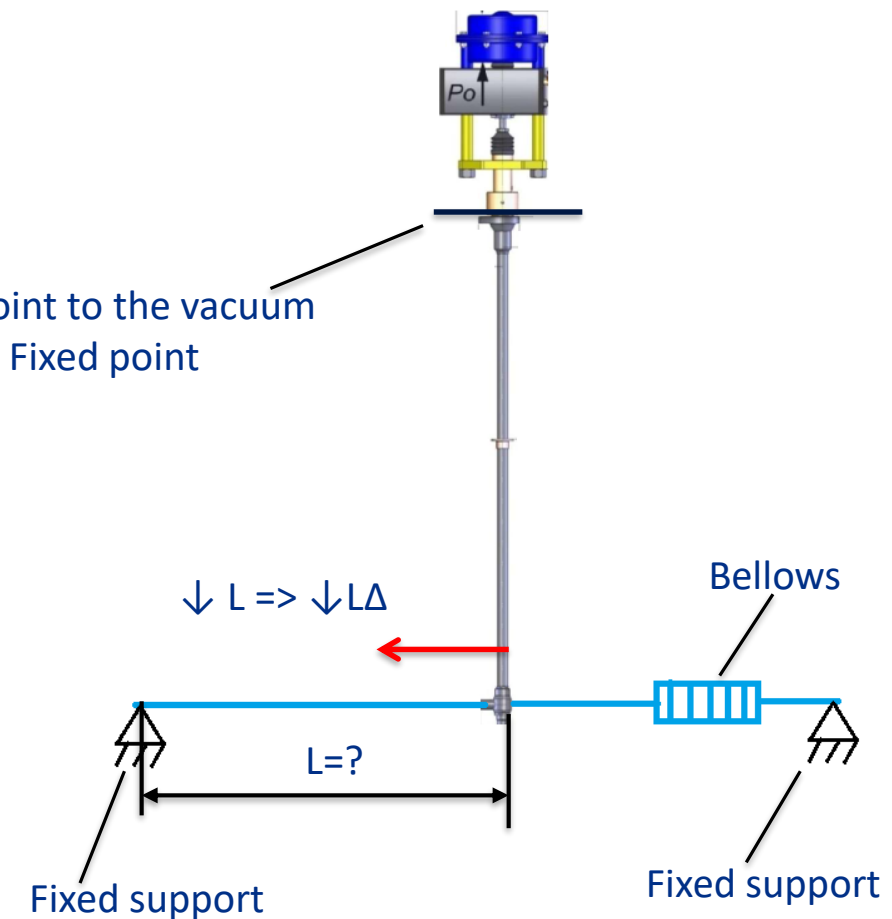
$E$  - Young's modulus,

$F$  - tensile force

$S$  - cross-sectional area of pipe

$\sigma$  - tension

Weld point to the vacuum flange / Fixed point



- The force acting on the valve is independent of its position
- In order to reduce stress in the valve body, it is necessary to install it as close as possible to the fixed support (minimalization of  $\Delta l$ ) so that the deformation of the valve body remains at an acceptable level

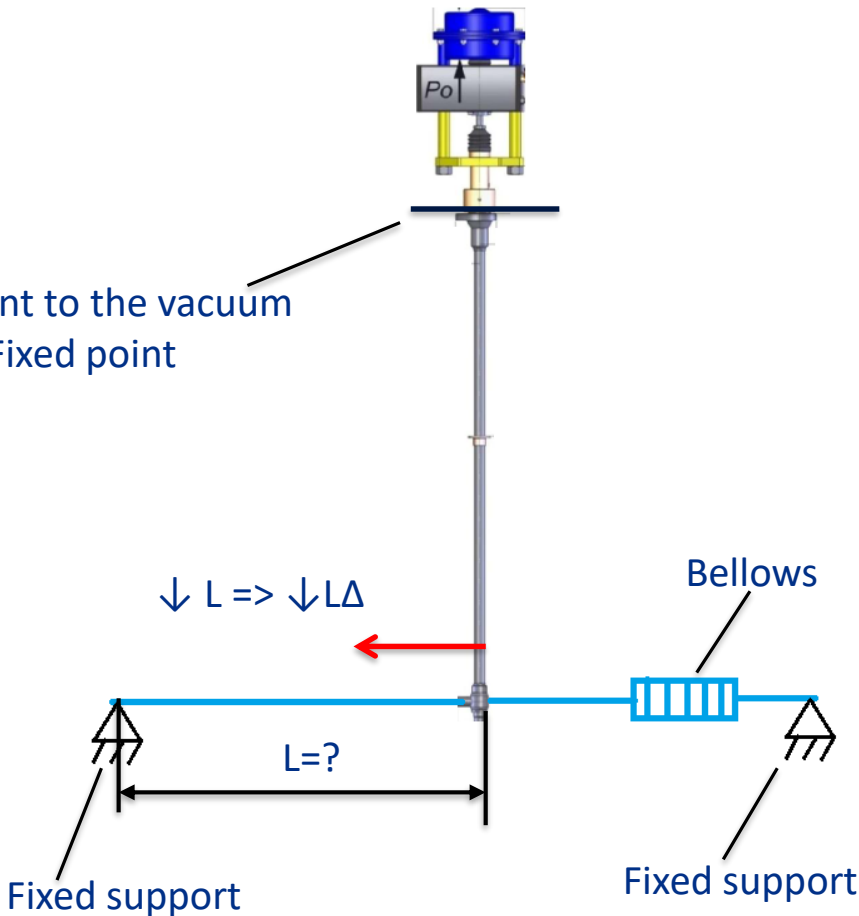
# Stresses generated by thermal contraction of the process pipe

WEKA Specification no. 20100223 - Allowed Piping Loads - Allowed Displacement:

Size DN	Pressure PN	Outside Dia. body tube <i>mm</i>	Wall thickness body tube <i>mm</i>	Moment of inertia of area I <i>mm4*10E3</i>	Section modulus Wb <i>mm3*10E3</i>	r-max for reference only! <i>mm</i>	Cryogenic length <i>mm</i>	E <i>kN/mm2</i>	F(max) <i>kN</i>	Mb(max) <i>Nm</i>	σb(max) <i>N/mm2</i>
DN2	PN25	14.0	1.00	0.9	0.3	3.0	875.0	205'000	0.002	0.002	16.56
DN4	PN25	14.0	1.00	0.9	0.3	3.0	875.0	205'000	0.002	0.002	16.56
DN6	PN25	14.0	1.00	0.9	0.3	3.0	875.0	205'000	0.002	0.002	16.56
DN8	PN25	16.0	1.00	1.3	0.4	3.0	875.0	205'000	0.004	0.003	18.93
DN10	PN25	18.0	1.00	1.9	0.6	3.0	875.0	205'000	0.005	0.005	21.29
DN15	PN25	24.0	1.00	4.8	1.4	3.0	875.0	205'000	0.013	0.012	28.39
DN20	PN25	32.5	1.00	12.3	3.4	3.0	875.0	205'000	0.034	0.030	38.44
DN25	PN25	38.0	1.20	23.5	5.4	3.0	875.0	205'000	0.065	0.057	44.95
DN32	PN25	43.5	1.50	43.7	8.1	3.0	875.0	205'000	0.098	0.086	50.86
DN40-rb	PN25	48.3	1.60	64.1	11.1	3.0	875.0	205'000	0.176	0.154	57.13

The allowable displacement for valves with G10 stems is the same as for valves with steel stems - information confirmed by WEKA

Weld point to the vacuum flange / Fixed point

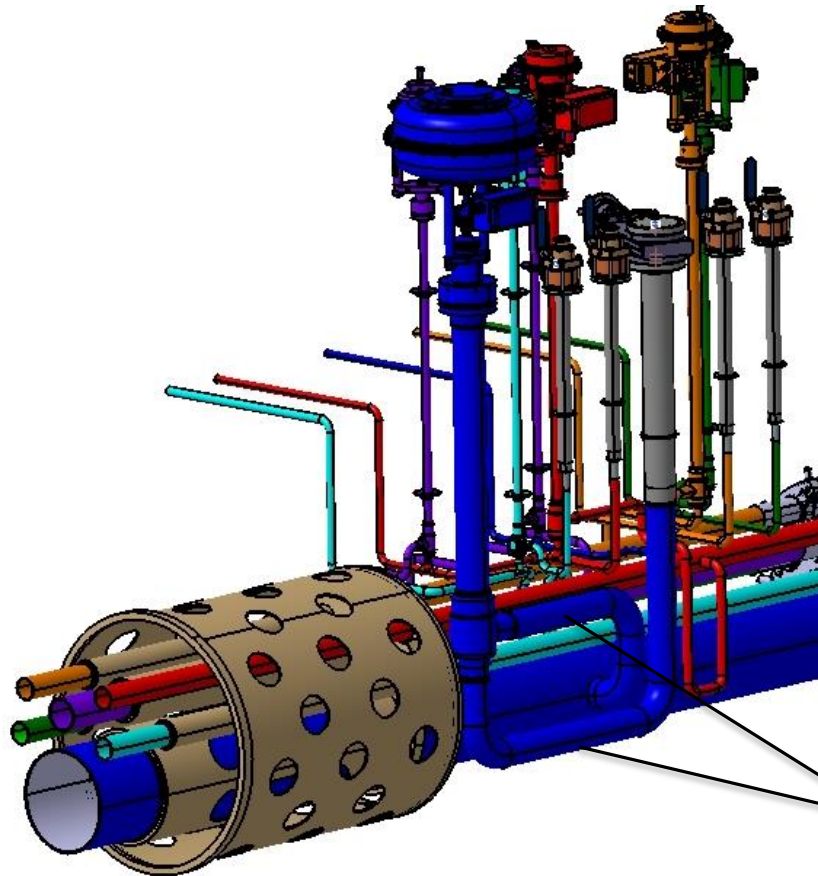


- The force acting on the valve is independent of its position
- In order to reduce stress in the valve seat, it is necessary to install it as close as possible to the fixed support (minimalization of Δl) so that the deformation of the valve seat remains at an acceptable level

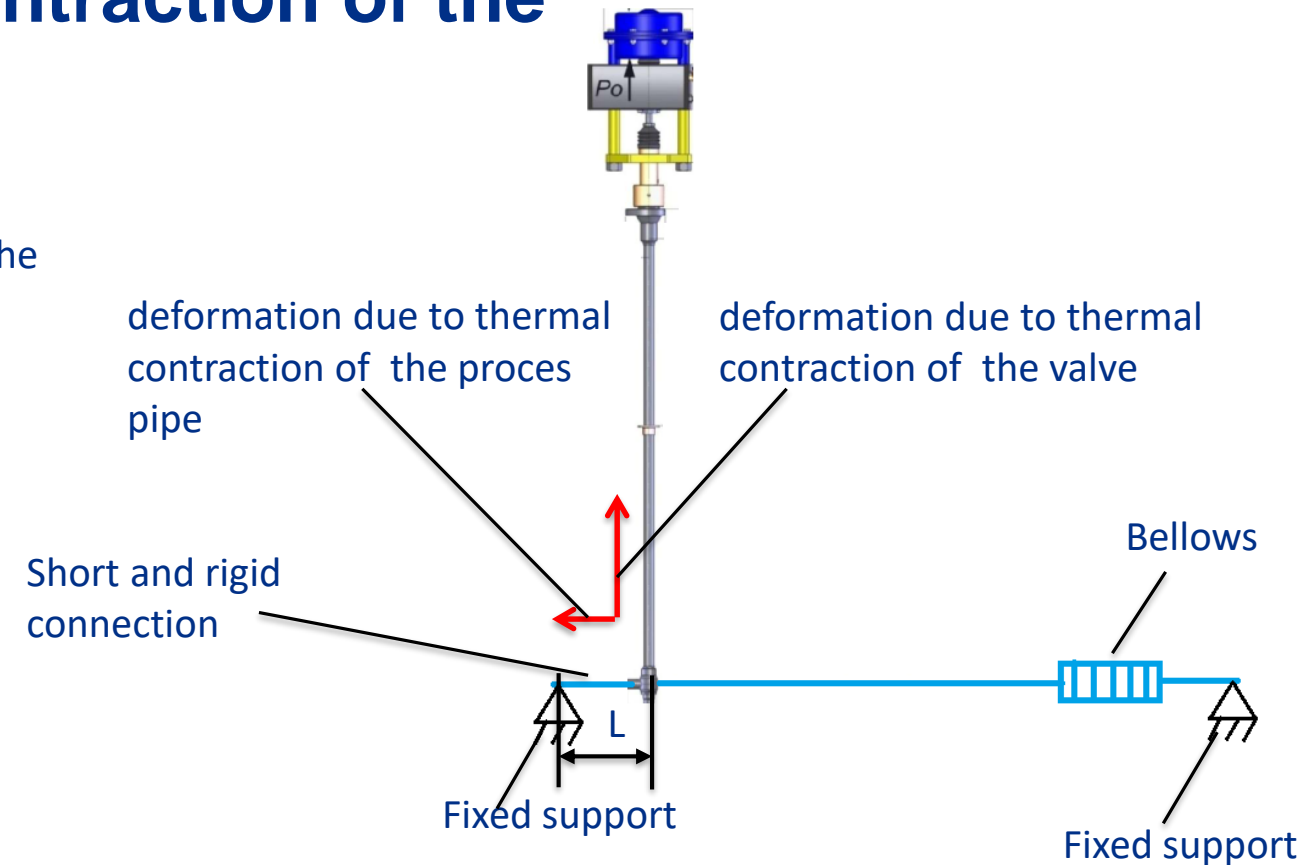


# Stresses generated by thermal contraction of the valve body

Limiting deformation of the valve body in the horizontal axis causes increase in stresses generated as a result of thermal contraction of the valve in the vertical direction

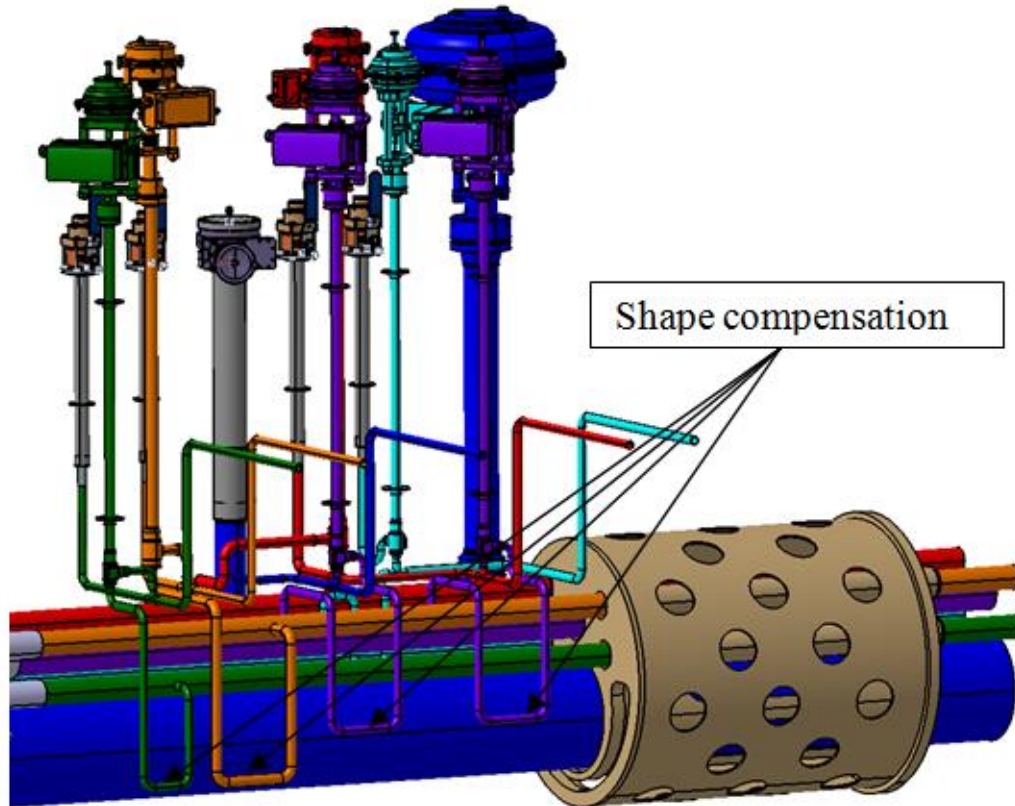


The use of a compensation loop allows to limit the stresses resulting from thermal contraction of the valve body or bayonet connector

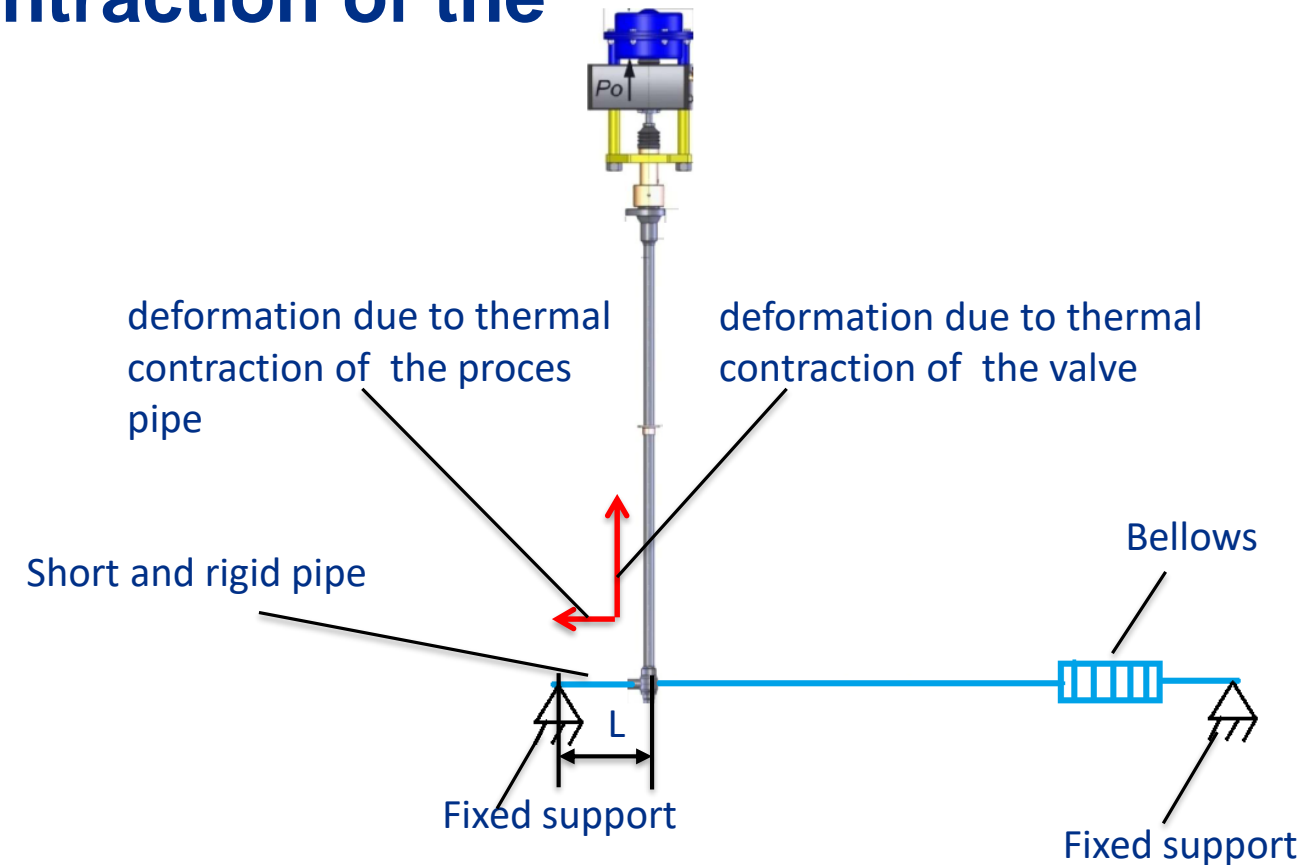


# Stresses generated by thermal contraction of the valve body

Valves and bayonets with smaller diameters can be installed further away from the fixed support due to the greater flexibility of smaller diameter process pipes



In the case of pipes with small diameters, the design of the compensation loops is very simple



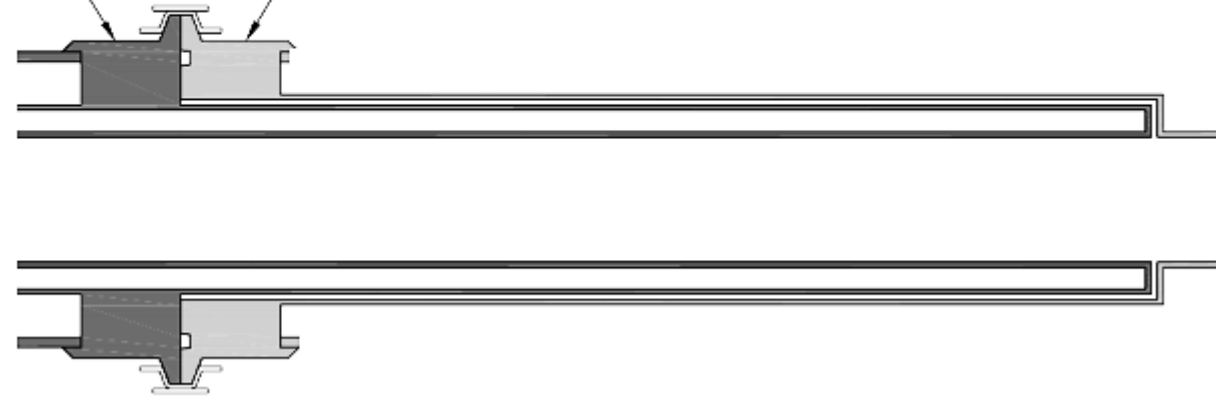


# How to modeling a valve and bayonet for FEA

Each valve can be successfully modeled as a tube - the dimensions of the valve body tube should be taken. In this case, the valve stem does not participate in the mechanical analysis.

Size DN	Pressure PN	Outside Dia. body tube <i>mm</i>	Wall thickness body tube <i>mm</i>	Moment of inertia of area <i>I</i> <i>mm</i> <sup>4</sup> <i>*10E3</i>	Section modulus <i>Wb</i> <i>mm</i> <sup>3</sup> <i>*10E3</i>	r-max for reference only! <i>mm</i>	Cryogenic length <i>mm</i>	E <i>kN/mm</i> <sup>2</sup>	F(max) <i>kN</i>	Mb(max) <i>Nm</i>
DN2	PN25	14.0	1.00	0.9	0.3	3.0	875.0	205'000	0.002	0.002
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MALE BAYONET FEMALE BAYONET

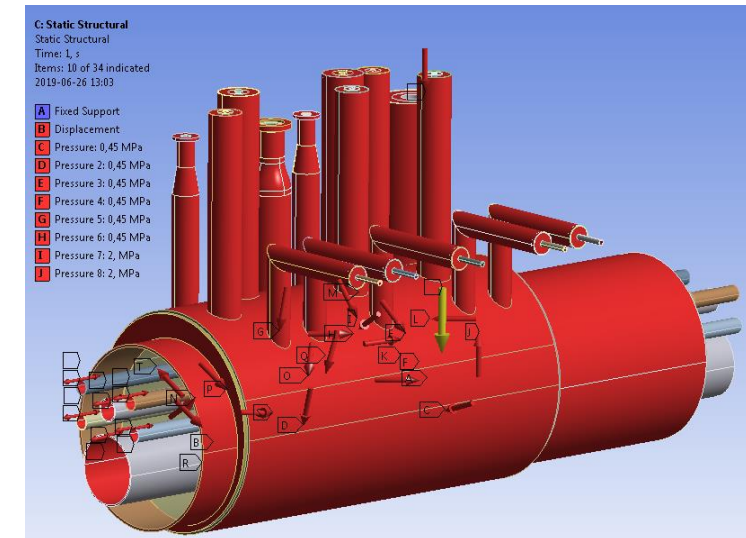
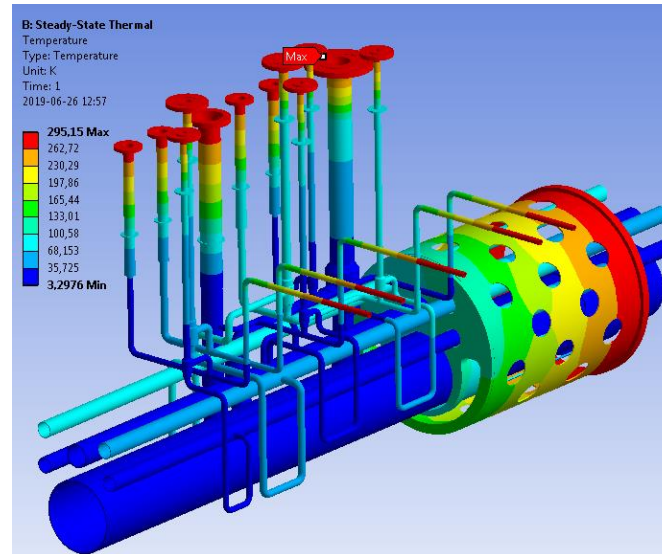
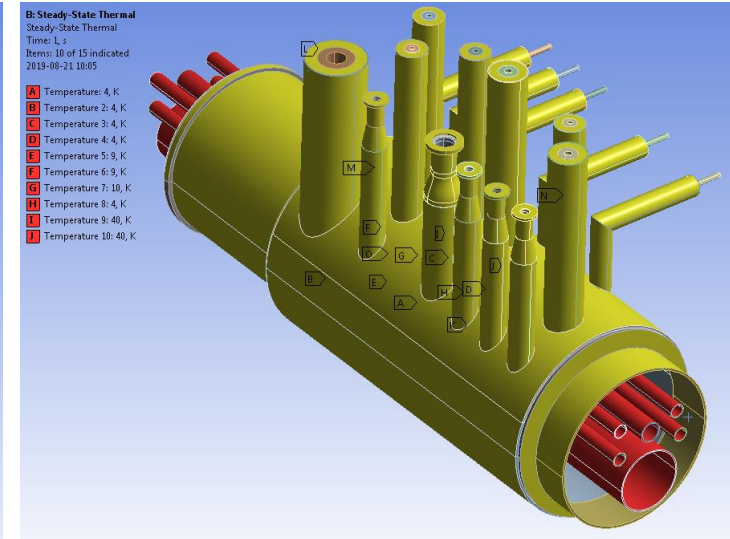
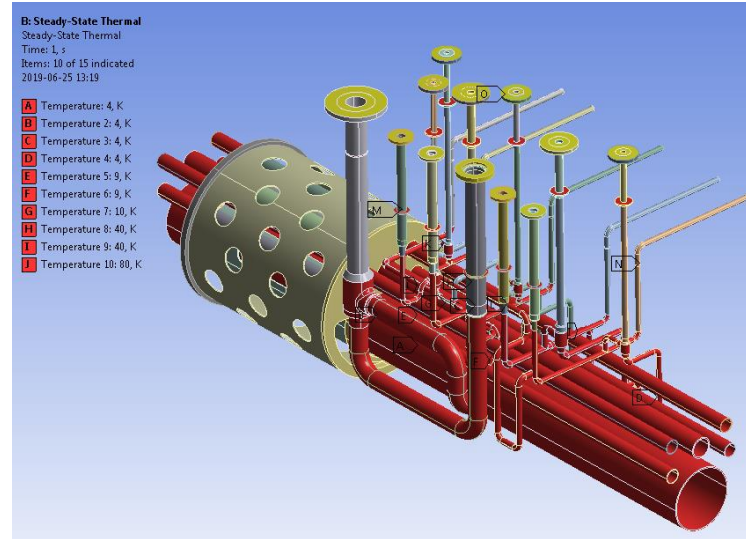


For bayonets, modeling only the female connector is a more conservative approach.  
The male and female bayonet joint together have higher stiffness.

# Stress and deformations of bayonets and control valves on example the Bayonet Can

Boundary conditions for thermo-mechanical analysis model:

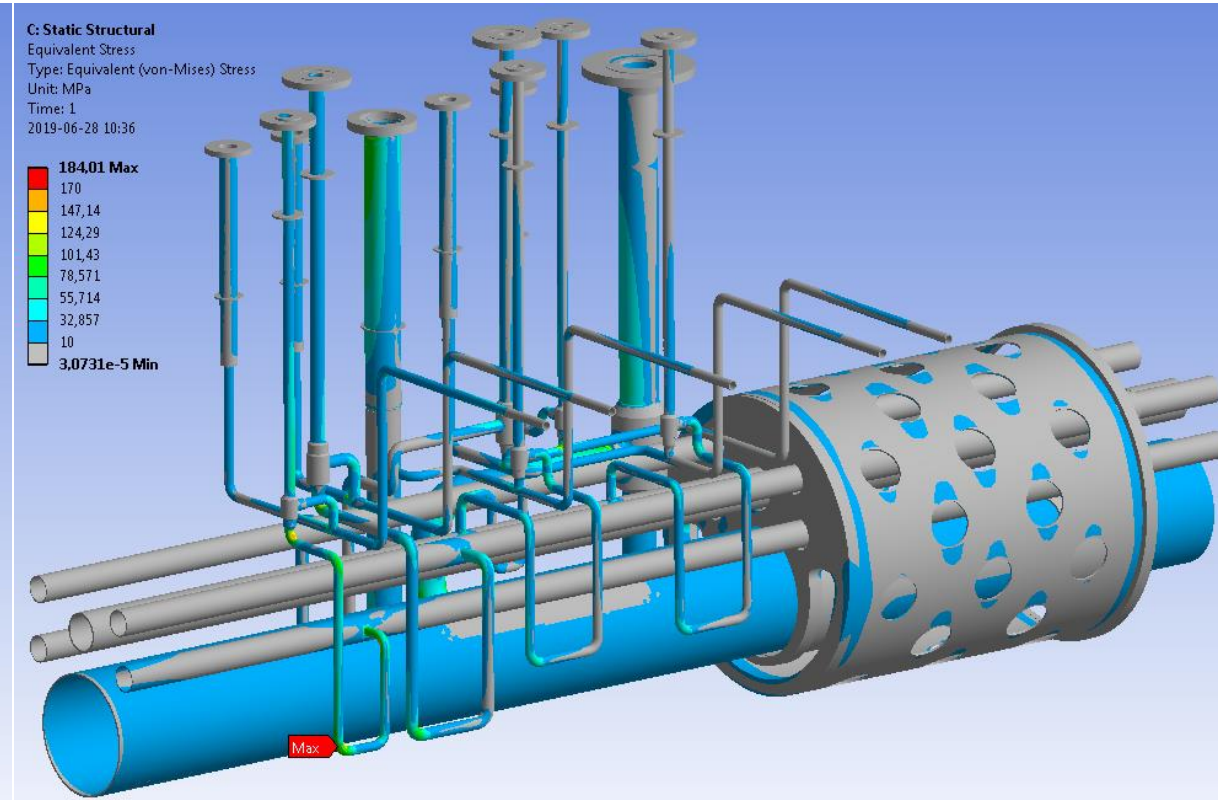
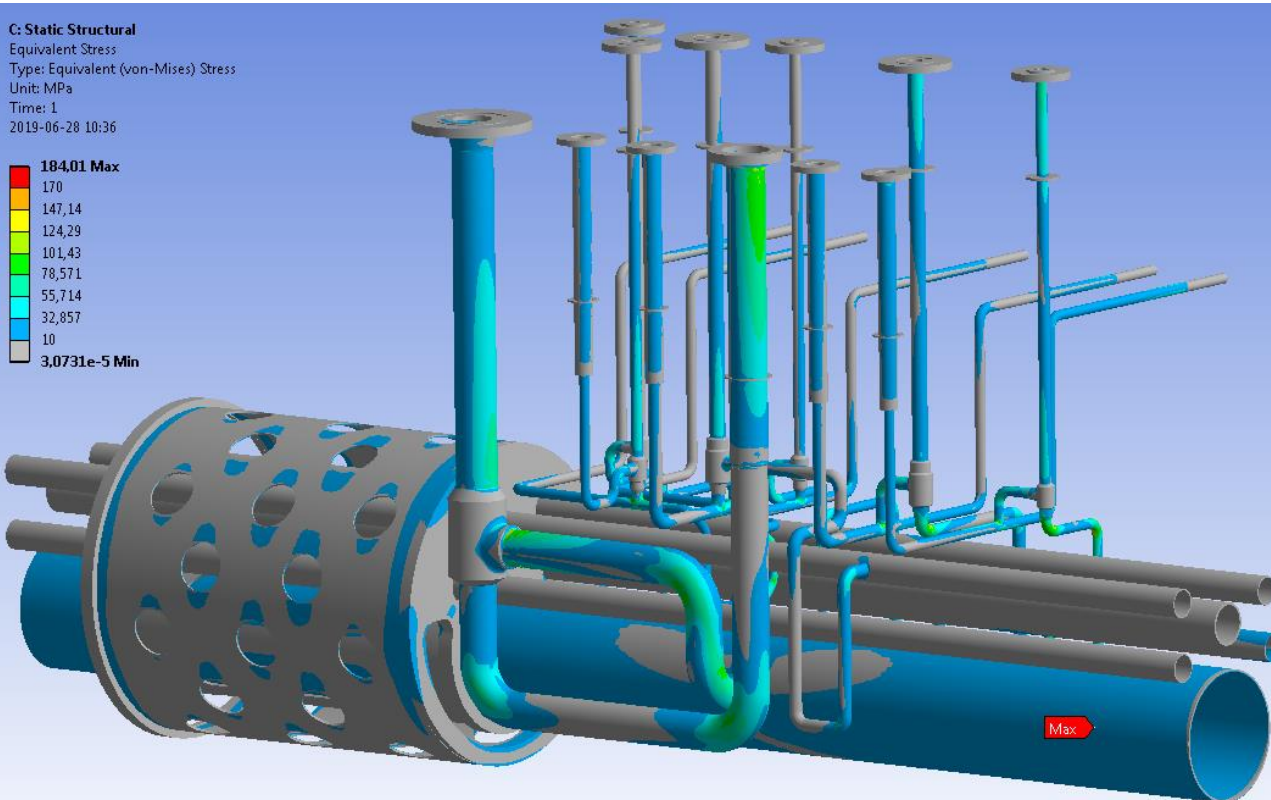
- Thermal analysis
  - nominal temperatures on all process pipes,
  - free convection on the outer surface of the vacuum jacket
- Mechanical analysis
  - calculation pressure PC in all process pipes,
  - the temperature field from thermal analysis
  - standard Earth gravity
  - forces generated by expansion bellows on process pipes



# Stress and deformations of bayonets and control valves on example the Bayonet Can

## Mechanical analysis results - Expansion stress

The maximum value of the expansion stress is 184 [MPa] (The maximal allowable expansion stress ( $f_a = 198.5$  MPa))

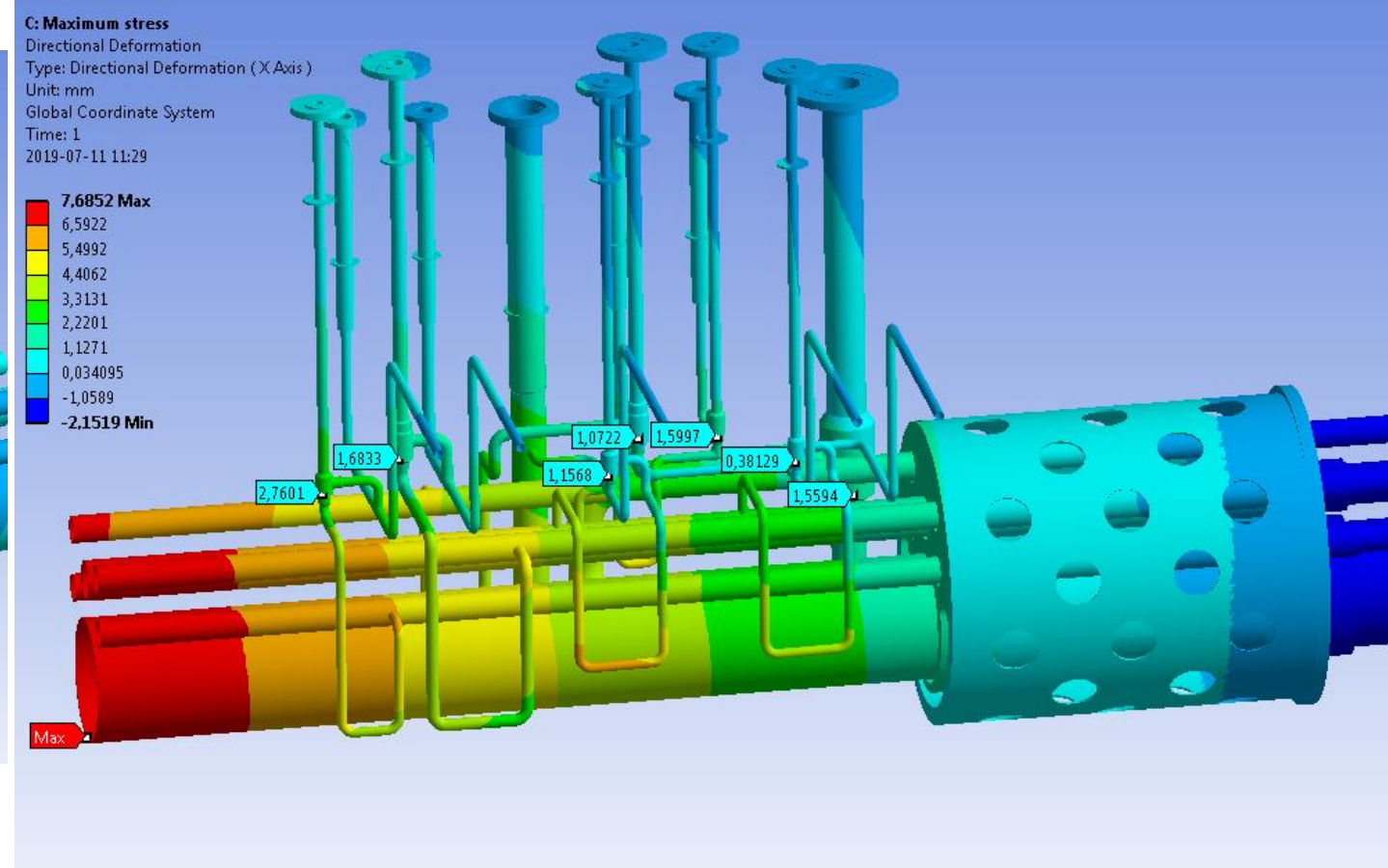
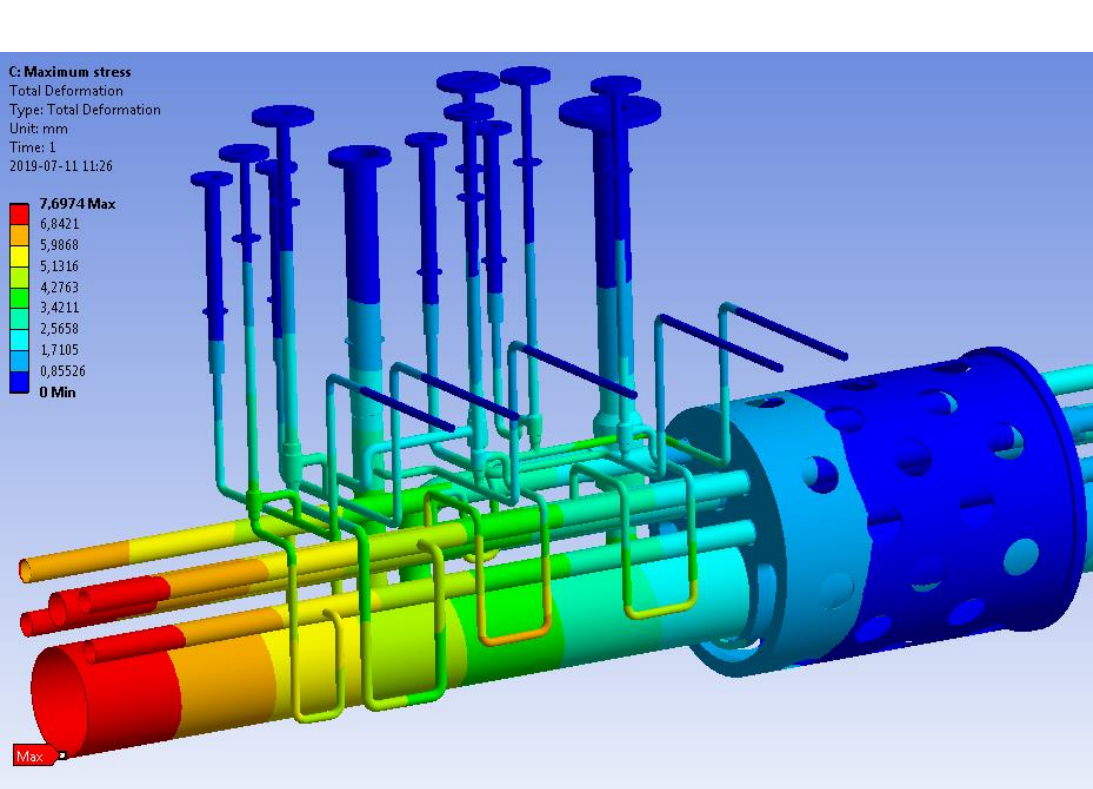




# Stress and deformations of bayonets and control valves on example the Bayonet Can

## Mechanical analysis results - Deformations

The maximum value of the valves bodys displacements are lower than the maximal allowable value (3mm)



# Summary

- 1. Stresses from the process pipes thermal contraction in valves bodies or bayonets can be minimized by reducing the distance of these elements from the fixed support.**
- 2. The stresses generated by the vertical contraction of the valves or bayonets can be minimized through compensation loops.**
- 3. Larger valves and bayonets should be installed as close as possible to the fixed support. Smaller diameter pipes are more flexible.**
- 4. The allowable displacement for valves with G10 stems is the same as for valves with steel stems.**
- 5. For bayonets, modeling only the female connector is a more conservative approach. The male and female bayonet joint together have higher stiffness.**

■

# Thank you for your attention